Part 1

Study 1: Effect of Sample Frequency and Filter Frequency on the Approximate Entropy Values for Isometric Force Records

ApEn has been used to quantify signal complexity in isometric contractions and distinguish between patient groups. Sampling frequencies, *'r'* values (a parameter needed in the ApEn algorithm which essentially accounts for the noise in the signal Pincus1991 and filters may affect signal characteristics reflected in an alteration in ApEn values and subsequent patterns of results. However there is little standardisation of such procedures for this measure. The purpose of the was to investigate the effect of the choices on ApEn values. While the 'true' ApEn value cannot be known the approach taken here was to start with the highest resolution signal and to identify the pattern of ApEn results across different percentages of maximum voluntary contraction and then assess the effect of the post-processing changes on this pattern. The results show the choice of sample rate and *'r'* is critical in reliably determining changes in ApEn with effort level. It is suggested that *'r'* used should be, if possible, a measured estimate of noise, sample rates should be as high as possible and filter cut-offs should not be lower than [40]Hz.

Study 2: Effect of Bimodal Stimulus on Force Control of Elderly and Young Adults Research shows that older adults often exhibit reduced irregularity in force signal data during isometric contractions (e.g. Sosnoff2006. The purpose of this study was to examine magnitude of variability and structure of isometric force data using appropriate post-processing methods previously established in *Study 1.* Differences in structure of force output between old and young adults may be as a result of older adults having reduced visuomotor processing capabilities, therefore a second purpose was to assess this by providing three different types of stimuli: 1) audio 2) both audio and visual (bimodal) 3) visual. Young (18-25) and old (65-72) neurologically healthy adults produced isometric force contractions using abduction of the FDI at six force levels (5, 10, 25, 40, 50 and 75% MVC) during each of the three conditions. There were no differences found in magnitudes of variability between the age groups nor was there any alteration in force output in the bimodal condition compared to the visual condition for either of the groups. The audio condition altered all indexes of force structure and variability significantly. ApEn values were significantly higher in younger adults at force levels >25% MVC during all conditions indicating higher irregularity than older adults (mean across all conditions and force: old=0.15, SD 0.11 young=0.19, SD 0.13). These results support the postulation that reduced complexity occurs with ageing. As the force signal is more pattern like it may result in a reduced ability to alter force production when required leading to a lower level of functionality.

Study 3:Decreased ApEn values in older adults are associated with increased time to achieve steady muscle force following a change in required force.

It was hypothesised that lower ApEn values would be associated with a reduced

ability to adapt to a required force change. ApEn of the force signal, functional reaction time, and time to reach a steady state at the new force target was measured. Two different types of stimulus were presented to participants as force targets, bimodal and visual. Young (18-25) and old (65-72) neurologically healthy adults produced isometric force contractions using abduction of the FDI at six force levels that either increased, or decreased at a random interval. Increasing force levels were 5 to 25%, 25 to 50% and 25 to 75% of MVC and decreasing force levels were 25 to 5%, 50 to 25% and 75 to 25% of MVC. Confirming our hypothesis, older adults exhibited longer times to reach steady state, even after removal of reaction time at force levels initiated above 5% MVC. Mean time to reach steady state (minus reaction time) was [2.83]s for young subjects and [3.23]s for old adults [t=2.14, p=0.03]. These results did not differ whether force target moved up or down. These results provide evidence to support the concept that reduced irregularity leads to decreased adaptability to task alterations. This knowledge may be beneficial when modelling ageing movement and force production or used as a pre-clinical tool for identifying those at risk of falls etc.

Part 2

Study 4: The determination of Body Segment Inertial Parameters of young female club level athletes Body segment inertial parameters (BSIPs) must be determined to perform biomechanical analyses. Geometric BSIP models are cost effective, yet collecting the anthropometric data necessary is time consuming and time with athletes is often limited. Also, few anthropometric models have been validated for female athletes. The purpose of the study was to validate a geometric model for female club and college athletes. A total of 118 anthropometric measurements were taken from thirty female participants. The upper arms, forearms, hands, thighs, shank and feet were each modelled using four shapes per segment in the full model, and two shapes per segment in the reduced model. The trunk segment was modelled as a series of ten stadium solids in both models. Further refinements of the present model addressed the shoulder area reducing overlap of trunk and upper arm segments. The geometric model predicted segment volume and which was multiplied by cadaver derived density functions Clauser1969 to determine segment mass. The root mean square error between actual whole body volumes (WBV), determined using a hydrostatic weighing tank, and predicted WBV was 2.37%, 3.03% and 2.34% of WBV for the full, reduced and basic models respectively. The model predicted trunk mass with RMSE of just 3.49% of segment mass compared to DXA measured trunk mass. Pearsons correlation showed high correlation between the segment masses predicted by the full model and DXA measured mass [r values ranged from 0.727-0.893, $p<0.001$] for the upper arms, forearms, thighs, shanks and feet. The full and reduced model showed high correlation for all segments [mean r=0.9100, $p<0.001$] which confirms that reducing the number of anthropometric measurements taken from the limb segments (reducing required measures from 118 measures to 94) causes little difference in the predicted mass for limb segments. These results are of interest to sports biomechanists who are

without access to direct imaging techniques, but who wish to compute subject specific BSIPs.